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TABLE OF CONTENTS

Cleaning Farmers' Stock Peanuts . . . 3

Solvent Extraction of Oilseeds . . . 5

Dam Checking by Hydraulic Models . . 7

Digests of Chemistry Theses 15

GOVERNMENT-FINANCED RESEARCH

Our cover photograph shows the rotary disc screen developed at the State Engineering Experiment Station for cleaning and sizing peanuts. Two other new peanut cleaning machines developed during prosecution of research for the Georgia-Florida-Alabama Peanut Association and the U. S. Department of Agriculture are described in the article beginning on page three. The Georgia Tech high-speed peanut planter has already proved itself in field trials. These machines are the fruits of research largely financed by government funds.

There is need for *government-financed* research wherever the fields requiring study are so broad that a single company or even an association of companies cannot afford to explore fully the potentialities of a comprehensive, coordinated research program. Providing funds for such programs is one of government's most valuable services to the people it represents, since development or expansion of even a single industry inevitably affects all beneficially, albeit indirectly in the case of most. More and better products are made and sold; more and better paid workers buy more things; more money circulates; and farmer, shopkeeper and banker alike find their businesses expanding, perhaps without realizing clearly how instrumental research has been in bringing about this happy situation.

When created by act of the Georgia Legislature in 1919, the State Engineering Experiment Station was charged with undertaking research for the development of Georgia's natural resources and the promotion of her industries. To date, appropriations have been insufficient in magnitude and regularity to permit a sustained, systematic research program of the type envisioned in 1919 and essential today.

Continued on Page 24

Our country's fine engineering schools have contributed much to her pre-eminence among the nations of the world by fertilizing her ever expanding industries with trained new men, on the one hand, and with new knowledge gained from research, on the other. Perhaps in no other places are so much specialized knowledge and so many skills assembled together. Their potential for productive research is an immeasurable asset of our nation. Georgia Tech, with its State Engineering Experiment Station, Daniel Guggenheim School of Aeronautics, A. French Textile School and many fine engineering and science schools, stands high among the "Institutes of Technology" which will continue to contribute to our country's progress through the time-tested avenues of education and research.

BLAKE R. VAN LEER,

President, Georgia Institute of Technology

CLEANING FARMERS' STOCK PEANUTS

By THOMAS A. ELLIOTT *

Georgia's 300,000-ton per year peanut crop, second only to cotton among the state's major agricultural products, annually earns some $60,000,000 for Georgia farmers and provides a substantial source of income for numerous industries and businesses of the Southeastern area. Speedier, more efficient methods and equipment for freeing stock peanuts from foreign material, now a costly and time-consuming operation, promise increased revenue to all concerned—simplified preparation for end use inevitably being a key to greater demand. The following article describes the peanut-cleaning aspects of research performed jointly by Georgia Tech's Engineering Experiment Station and the Georgia Experiment Station as part of a larger study of the problems involved in picking, transporting, receiving, handling, storing and shelling of peanuts—a project sponsored by the Georgia-Florida-Alabama Peanut Association and the United States Department of Agriculture.

For background, before describing our work on peanut cleaning, it may prove interesting to trace the path which a peanut follows from planting to the end-use processor. Peanuts are planted in the spring, are dug in August and September and, still on the vine, are stacked or windrowed and left in the fields to cure. They are later threshed and then graded to make the proper allowance for sound mature kernel content, and suitable deductions for damage, foreign material and moisture content. Grading and transactions between buyers and sellers consume roughly a month and a half. The peanuts are then placed in storage until

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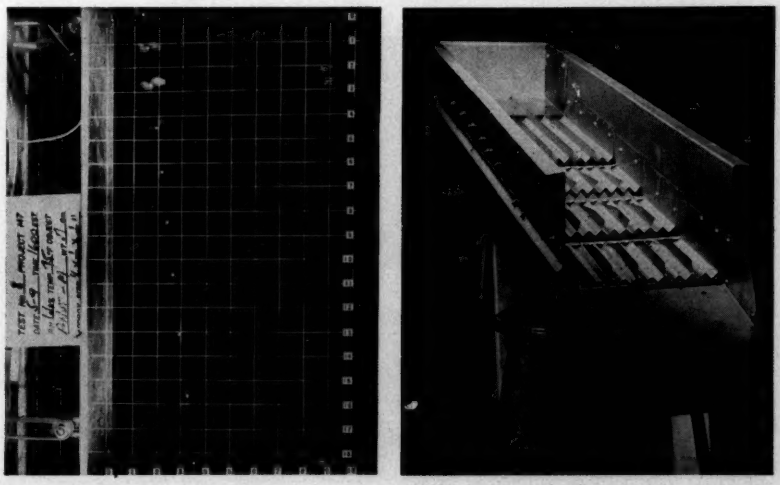

Figure 1. The electrostatic cleaner (left) effects separations of one inch between peanuts and foreign matter in falls of 18 inches. The V-corrugated slot screen (right) is another cleaning device.

accepted by the shelling plant where they are further cleaned of foreign material, shelled and separated from the loose shells. Following these steps, they are sized, picked for quality, sacked and shipped to the end-use processors where they are converted to peanut butter, candy, salted peanuts and peanut oil.

From the time the peanuts are threshed from the vines until they reach the end-use processor, foreign matter such as rocks, dust, sticks, etc. must be removed, since such material affects the grade prior to sale, slows and causes breakage in the shelling operation, and must be removed by hand in the picking operation. The optimum place to clean peanuts would be on the farm at threshing time. But, since the cost of currently available machines would prevent their use on a large number of farms, it seems that the most feasible place for cleaning peanuts is the shelling plant. The ideal hypothetical machine would clean a large volume of peanuts in a minimum of time, so that reasonably large samples would be available for grading. Where large tonnages must be purchased in small lots and in a relatively short time, present samples, in many cases, are not truly representative and cause either the buyer or the seller to suffer a loss. The ideal machine should also be sufficiently versatile to be adapted, in time, to use on the farm as well as in the shelling plant.

METHODS INVESTIGATED

In cooperation with the Georgia Experiment Station, the Georgia Tech Engineering Experiment Station is investigating three general methods for removing foreign matter from peanuts: washing and drying, electrostatic cleaning and mechanical cleaning.

Washing and Drying

Initial tests were conducted to determine whether or not washing and drying of whole peanuts promised an attractive method of cleaning. These tests investigated the relationship between rise in temperature of the kernel and the time the whole peanut is in an oven. Another factor considered was the amount of moisture absorbed by the shell and kernel when immersed in a water bath. Results in both cases were favorable, and a washer was constructed which subjected the peanuts to a water bath, a needle spray and shaking to dislodge excess moisture. The peanuts were then run through a rotary kiln and dried to the desired moisture content. No apparent damage to quality or taste of the peanuts resulted, although there was a five per cent loss in germination. The estimated processing costs of such an operation are within reason. However, the initial cost of the drying equipment is comparatively high and might deter adoption of the method by the industry.

The advantages of washing and drying peanuts are: (1) positive separation of rocks and dirt from peanuts; (2) possible hardening or embrittling of shells to facilitate shelling; and (3) wetting of kernels prior to shelling with resultant reduction in kernel splitting during the shelling operation.

Electrostatic Cleaning

The possibility of cleaning peanuts by electrically charging both nuts and foreign material and dropping them through an electrical field to attain separation was investigated when a search of the literature revealed that little work in this field had been done with objects of the size and nature found in farmers' stock peanuts.

The model electrostatic cleaner constructed at Tech consists of two adjustable aluminum plates, a variable power supply producing 5,000-39,000 volts DC and the meters and resistors necessary to indicate voltage and current. A thread grid behind the plates was used as a reference when test drops were made and numerous multiflash photographs similar to that shown in Figure 1 were taken. These tests showed that separations of one inch between stones and peanuts and between peanuts and sticks could be made in falls of 18 inches through the electrical field. Since practical application of this method would require considerably more research than provided for under the existing budget, further tests have not been undertaken.

Continued on Page 17

SOLVENT EXTRACTION—A NEW METHOD IN AN OLD INDUSTRY *

By E. P. COFIELD, JR. **

Solvent extraction, a method of processing oilseeds which has heretofore been confined largely to the Midwest, is beginning to move South. In view of the recognized importance of Southern oilseeds—cottonseed and peanuts—the following survey of the technological and economic aspects of this process is indeed timely.

Oilseeds, which may be considered to include such diverse products as beans, nuts, and kernels in addition to seeds, have been processed for the purpose of obtaining their oil content since at least the beginning of recorded history. The oils thus obtained have been used at one time or another for varied purposes—as food, as fuel, in cosmetics, in the manufacture of soap, as lubricants, and as essential ingredients in paints, varnishes and inks. In addition, the seed residues have been useful as stockfeed, fertilizer and, of late, as a source of industrial protein from which fibers and adhesives have been successfully manufactured.

Inasmuch as "cotton was king" in the South for about a century, a reign which ended with the advent of the boll weevil in the early 1920's, it is not surprising that the processing, or crushing, of cottonseed also became an important industry during this period. As a matter of fact, the terms "cottonseed" and "oilseed" were for all practical purposes synonomous, insofar as commercial operations were concerned, until about ten years ago when peanuts began to occupy a position of increasing importance as a source of oil. The develop-

*This article is a condensation of the State Engineering Experiment Station's recently published Circular No. 28, *The Solvent Extraction of Oilseed, An Informational Survey* plus additional information gathered by the author during the past six months.

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Soybean extraction plant of Spencer-Kellog & Sons, Bellevue, Ohio. Photograph by courtesy of the Blaw-Knox Company.

ment of the oilseed industry in this region may be considered to have begun in 1834 when, the majority of authorities agree, the first commercial cottonseed oil mill was established in Natchez, Mississippi. The number of mills increased slowly at first—there were only about 30 in operation in 1870—but, by 1914, 885 establishments were in production. The number of active mills decreased after 1914; the latest data at hand indicate that about 334 crushers were operating in this area in 1943. Oil production has remained fairly constant—the average for the period 1908-18 was 1352 million pounds annually while the average for 1939-43 was 1327 million pounds. Although there have been instances in which new mills were erected or old mills modernized during the past few years, the majority of our Southern mills are not of very recent vintage.

PROCESSING METHODS

Generally speaking, all oilseeds are processed by using, singly or in combination, two methods; namely, expression of the oil by means of mechanically applied pressure or extraction of the oil through the use of such solvents as petroleum fractions (largely hexanes or heptanes), ethyl alcohol or trichloroethylene.

Mechanical methods, in turn, may be divided into two general classes: those which are operated on a batch basis and those which are continuous in nature. Although batch methods have been employed for hundreds of years, the system most used in the South was developed initially about 1890 and is commonly referred to as the "hydraulic" process. Oilseeds processed by this method are usually rolled into flakes, cooked and then subjected to a pressure of about 4,000 psi in a press which is operated by means of a hydraulic ram. Despite numerous improvements which have been made since the method was introduced, hydraulic pressing is not a highly efficient operation since the residue, or meal, contains at least some six per cent oil and the labor requirement is comparatively high.

Continuous presses in which a rotating screw takes the place of the intermittently operated ram were introduced to the oil mill industry shortly after the turn of the past century. Although it is possible to reduce the oil content of the press cake to four or five per cent in a well run screw press, this type of equipment has never been widely used in the South.

The use of solvent methods dates from 1843 when one Jesse Fisher is said to have employed carbon disulfide for the extraction of olive oil. All of the early extractors were operated on a batch basis; and, although the residues from these units normally contained only about one per cent oil, they were not considered economically attractive for American use. The higher oil recovery apparently did not offset the higher operating cost. However, during the early 1920's a number of comparatively large-sized, continuous solvent extraction plants were built in Europe, principally in Germany, and the subsequent success of these operations attracted the attention of American processors. Since the German extractors were, for the most part, designed for the recovery of soybean oil, the first units to be erected (1934) in the United States were located in the Midwest where soybeans were, and still are, grown on a large scale. The solvent extraction of soybeans in America proved to be practicable from both the technical and economic viewpoints. The next 15 years saw the development of a number of extraction systems of American origin as well as the erection of numerous plants throughout the soybean growing area. The versatility of the process was increased—linseed, corn, castor, cottonseed, rice, peanut and tung oils have all been extracted on a commercial basis.

Although several different solvent extraction systems have been developed, all include four basic operations; namely, preparation of the seed, extraction of the oil, separation of the oil-solvent mixture (miscella) and recovery of the solvent from the residual meal.

Preparatory Operations

The ultimate objective of the preparatory operations is to create optimum conditions for the subsequent extraction of the oil. Details of these operations vary with the type of extraction unit employed and

Continued on Page 18

MODIFICATIONS OF DAM CHECKED BY HYDRAULIC MODELS †

By E. S. HARRISON* *and* C. E. KINDSVATER**

Before adding buttresses to strengthen the spillway section of its 25-year-old Bartlett's Ferry Dam, the Georgia Power Company requested the Georgia Tech Hydraulics Laboratory to investigate the proposed modifications by hydraulic studies of scale models. The Company's preliminary engineering investigations of this dam, the model tests and the remedial measures which were completed in September, 1950, are described in the following article.

The investigation reported in this paper was started in 1946, when the Georgia Power Company initiated studies to determine the adequacy of spillway capacity and structural stability of their major dams, all of which were built between 1900 and 1926. At the time some of these dams were built, rainfall and flood-flow records were of short duration. More recent and complete records show, for most sections of the country, rainfall and flood-flows much larger than those shown by the older short-period records. This investigation was made to determine the adequacy of the dams if subjected to the great storms of record which have occurred east of the Mississippi.

Bartlett's Ferry Dam alone was shown to require remedial measures. The estimated maximum flood at this plant resulted in a calculated reservoir level which would reach the top of the earth non-overflow sections of the dam. The studies also indicated that the spillway section of the dam should be strengthened to provide adequate stability.

Description of Bartlett's Ferry Dam

Bartlett's Ferry Dam, built for the Columbus Electric & Power Company in 1925,

†As presented before the Hydraulic Division, American Society of Civil Engineers, at Jackson, Miss., December 1, 1950, with the omission of several illustrations to meet space limitations.

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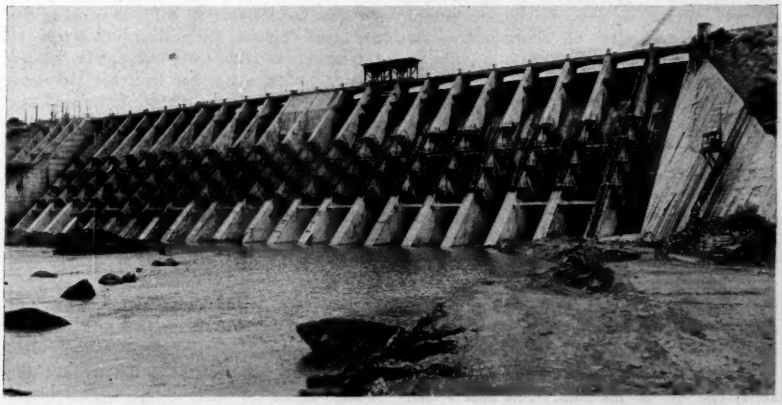


Figure 1. Bartlett's Ferry Dam as it looked near completion of modifications and after addition of reinforced-concrete buttresses.

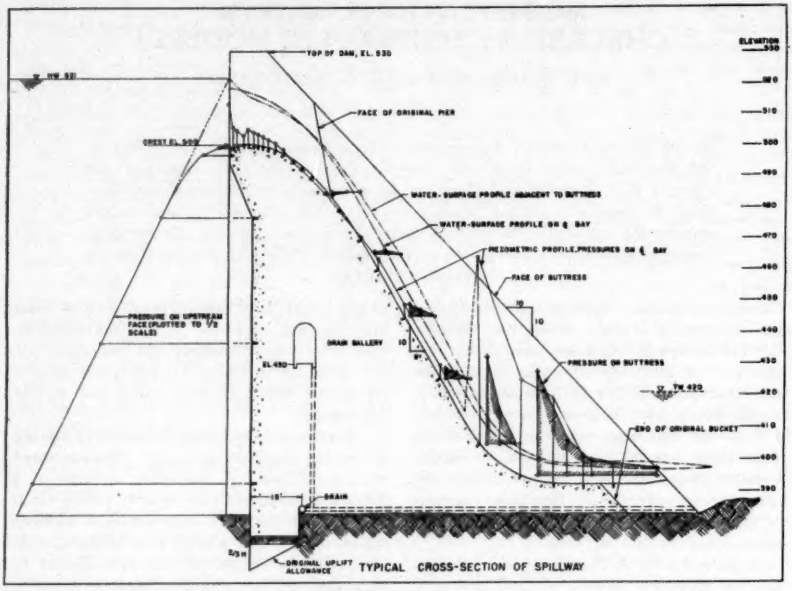


Figure 2. Cross section of spillway as originally designed and as modified by the addition of buttresses.

was purchased by the Georgia Power Company in 1929. It consists of a concrete gravity spillway section, a concrete intake section and two earth-fill abutments. The maximum height of the concrete spillway section, from the river bed to the normal pool elevation, is approximately 140 feet. Figure 1 is a general photograph of the project.

Figure 2 shows a cross section of the spillway of the dam as originally built and as modified by the addition of buttresses. This figure also shows the uplift assumption used in the original design. This assumption allowed for uplift pressure varying from two-thirds at the upstream face of the dam to zero at the longitudinal drain at the base of the dam, 15 feet downstream. It made no allowance for uplift pressure above the base of the dam. The base width used in the design was increased by utilizing a part of the bucket concrete. As no allowance for uplift was made above the rock contact line, the critical section of the dam is at elevation 400. Assuming 50 per cent uplift, the calculated stress at the upstream face is approximately 27 psi tension, with a normal reservoir elevation of 521, the level of the top of the spillway gates.

As there was every reason to believe that uplift water pressures existed in the concrete dam above the rock line, immediate steps were taken to relieve this pressure as much as possible. Three-inch holes were made with a diamond drill working from the drainage gallery, at elevation 430, downward into the rock foundation. The purpose of these drill holes was to relieve existing internal water pressure and, also, to determine, if possible, what the existing water pressures were. The internal water pressure conditions revealed by these holes were unusual, to say the least.

Drain Holes and Water-Pressure Observations

Thirty-one 3-inch drain holes were drilled vertically downward from the gallery in the spillway section of the dam. In 15 of the holes the drill struck water in such large quantities and pressures that it was necessary to discontinue drilling in these holes. This necessitated dividing the drilling work into two stages. Water flowed from 26 of the 31 holes drilled. This upward flow varied from a seep to a solid 3-inch jet, 59 inches high, at Hole No. 52. The flow from this hole was approximately 390 gallons per minute.

Figure No. 3 shows the locations, depths drilled, and the results of tests and observations for Stage 1 drilling. The water pressures measured at the holes are shown in the tabulation on Figure 3 in terms of percentage of full headwater. The holes shown as stopping above the rock line are those in which large flows were encountered. None of the holes drilled during either the first- or second-stage drilling showed excessive flows at or below the rock line.

The second-stage drilling consisted of pressure grouting the holes which had excessive discharges, redrilling and extending these holes into the rock foundation. After Stage 1, 17 holes had spouting flows, 11 holes had pressures equal to full headwater and 21 holes had pressures exceeding ½ full-headwater pressure. After the grouting and redrilling (Stage 2) was completed, none of the holes had excessive flows. Only one of the holes had a pressure which exceeded ½ full headwater and only five holes had pressures which exceeded ⅓ full headwater.

Nine 1½-inch diamond-drill holes were located midway between those 3-inch drain holes, which were grouted. The 1½-inch holes, drilled to test the effectiveness of the grouting operations, had small flows. In one of these test holes the drill recovered a core of grout which was approximately 3/16ths of an inch thick.

Three-inch holes were also drilled vertically downward from the crest of the dam into the drainage gallery. None of these holes had excessive flows.

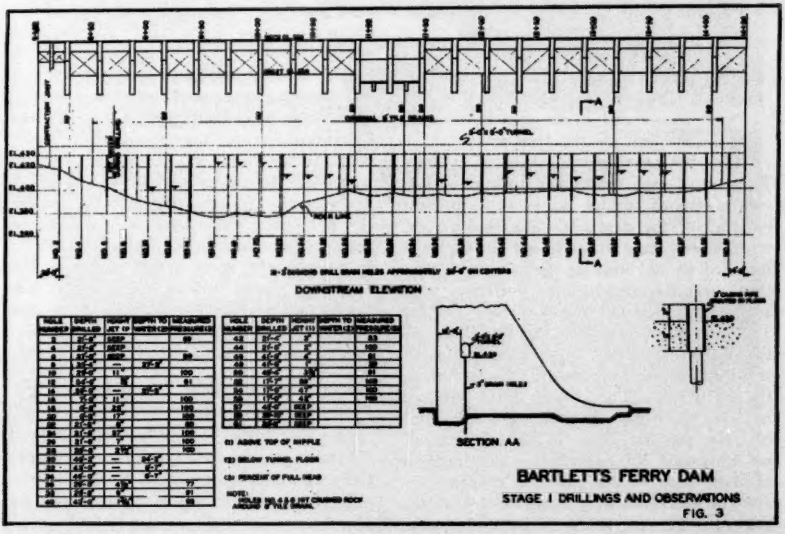


Figure 3. Locations, depths drilled and results of tests and observations for Stage 1 drilling.

Strengthening the Dam

The spillway section of Bartlett's Ferry Dam was strengthened by adding heavy, reinforced-concrete buttresses to the downstream face. The earth sections were strengthened by adding rock fills to the downstream faces, raising the crest elevation 5 feet and adding a reinforced-concrete wave wall, 4 feet high, to the top of the earth sections. Figure 1 shows the strengthened dam nearly completed.

The strengthened dam was designed to withstand a reservoir level 8 feet higher than that for which it was originally designed. At the higher pool level, the spillway capacity is 337,000 cubic feet per second, an increase of 68 per cent over original design capacity.

The redesign of the spillway section was based on the following assumptions:

(1) Buttresses to be added to the existing dam with the dam in a stressed condition;

(2) Load to be added to the buttresses by stress rods and sleeve nuts to make them carry a predetermined portion of the load;

(3) The total shear between existing dam and the buttresses to be carried by steel dowels; and

(4) Uplift pressure, at any horizontal plane, to vary from 50 per cent of full headwater to 0, or tailwater, and to be applied to 100 per cent of the base area.

The buttresses were added in blocks. The top of each block was formed to provide a smooth surface and oiled to prevent bonding of the next lift. Steel stress rods, with sleeve nuts at each lift joint, were installed to add load to the buttresses after they were completed. The buttresses were anchored to the existing dam by grouting 1¼-inch steel dowels 8 and 10 feet into the old gravity dam. The existing concrete was recessed an average of 6 inches under the buttresses. The dowels were designed to carry the total shear at the contact line between the old dam and the buttresses, no allowance being made for development of shear between old and new concrete.

The buttresses were constructed with the reservoir 11 feet below normal elevation. After all buttresses were completed, the reservoir was drawn down an additional 10 feet and the buttresses then loaded to predetermined values. The load was applied through the sleeve nuts by Torqometers. The Torqometers were calibrated in the Southern Research Institute laboratories, using ten sets of rods and sleeve nuts which were duplicates of those installed in the buttresses, to determine the consistency of the thread friction. The tests showed a very consistent relationship between rod loads and Torqometer dial readings. After the buttresses had been loaded and the slots left for the sleeve-nuts had been concreted, the joints adjacent to the old dam and, also, the buttress lift joints were pressure grouted.

MODEL TESTS

As studies for modification of the dam proceeded, the buttress design for spillway reinforcement appeared to be the most economical plan proposed; but some uncertainty arose concerning the effects of the buttresses on flow conditions in the area below the spillway. Although a negligible amount of river-bed scour had occurred in the immediate vicinity of the spillway during the life of the original structure, it was suggested that the "nozzling" effect of the buttresses might cause excessive scour below the dam, particularly since the effective flow width at the bottom of the spillway had been reduced approximately 28 per cent by the addition of the buttresses. Continued studies brought up other questions, including the magnitude of hydraulic forces on the buttresses, the design of the spillway bucket extension to accommodate the buttresses, the height and location of construction cofferdams, and the coefficient of discharge for the modified spillway. The need for model studies was clearly indicated, and arrangements were made to conduct tests in the Georgia Tech Hydraulics Laboratory.

Background for Model Studies—Prototype Experience

As Bartlett's Ferry Dam had been in operation for over 20 years, model observations could be interpreted in the light of numerous recorded experiences, adding significance to the conclusions. A brief review of these operating conditions and experiences

may prove helpful in understanding the model test program.

As constructed, the original structure did not include the customary elaborate provisions for the development of a stilling basin below the spillway, despite the abnormally low tailwater depths which occur at the site. Thus, for practically all conditions of operation, the tailwater was swept off the spillway bucket, exposing foundation rock near the toe of the dam to high-velocity flows. During the period of record, however, no significant movement of foundation rock had taken place, and erosion in the vicinity of the dam had never been a serious problem.

During the time that the project had been in operation, several large floods were experienced. These included the flood of March, 1929, when the peak spillway discharge was estimated to be approximately 135,000 cfs. Of greater significance, perhaps, is the fact that several gates had been opened a considerable portion of each year in order to pass normal flows. Early observations during high flows at the dam indicated that excessive spray and wave action made it undesirable to open spillway gates in the vicinity of the power house. Following the flood of 1929, the power-house training wall was raised five feet to prevent over-topping during high flows.

The normal power-pool level for the Bartlett's Ferry Project is at elevation 521, top-of-gates level. The revised maximum flood-pool level is at elevation 530. Maximum spillway discharge capacities are computed on the basis of 19 full spillway bays, two trash gates and four syphons, all in operation. The combined capacity of the trash gates and syphons is very small. The syphons, which occupy a width equal to two spillway bays, are normally closed but can be opened for flood discharge. In recent

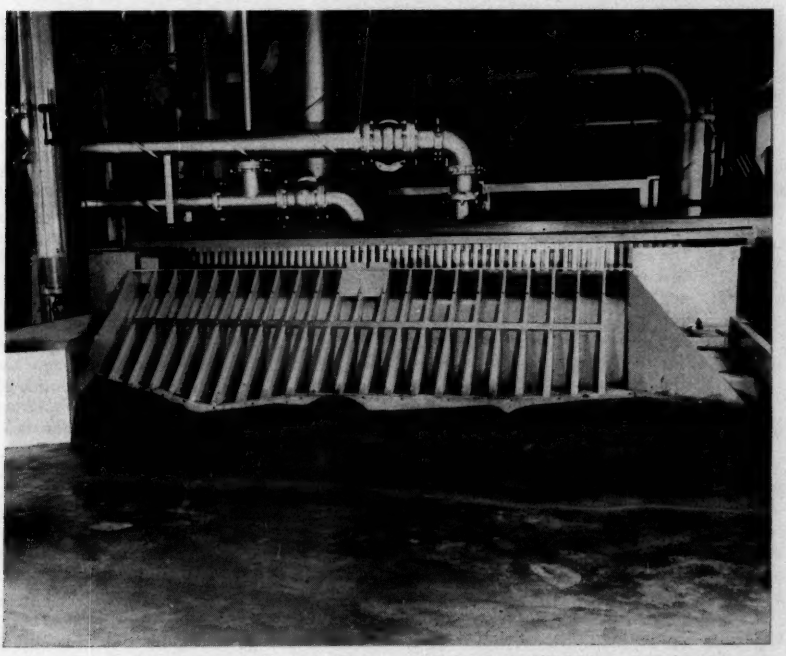


Figure 4. The 1:80-scale model of the modified dam.

years, the last gate on the east end of the spillway has been opened only occasionally, in order to avoid concentrations of flow along the foot of the retaining wall.

1:80-SCALE MODEL TESTS

Two models were constructed, the first of which was a 1:80-scale comprehensive model of the spillway and power-house sections of the dam, plus a section of the river area extending approximately 700 feet (prototype) downstream from the dam. The model was located in a steel flume specially designed for this project. The spillway crest gates were numbered from 1 to 19, beginning at the power-house end of the dam. One bay adjacent to the power-house, which is occupied by trash gates, was reproduced as an additional spillway bay, and was designated by the letter "T". Two bays representing the syphons were designated "S_1" and "S_2", reading from west to east. The proposed buttresses, each of which required special fitting to conform to the irregular spillway bucket, were constructed of plywood and were assembled as a single unit to facilitate installation. Riverbed topography was reproduced in concrete except for scour tests, during which a short section of the bed immediately below the spillway was composed of pea gravel. Figure 4 shows a 1:80-scale model of the modified structure.

The objectives of tests on the 1:80-scale models were as follows:

(1) To contrast flow conditions below the original spillway structure with conditions which might occur if the buttresses were added;
(2) To develop a satisfactory design for the spillway bucket extension;
(3) To determine a satisfactory gate-opening sequence for passing flood waters over the spillway;
(4) To explore the necessity for raising the original power-house training wall, and to develop a satisfactory design for this modification, if required; and
(5) To determine the best location and height of cofferdams for two-stage construction of the buttresses.

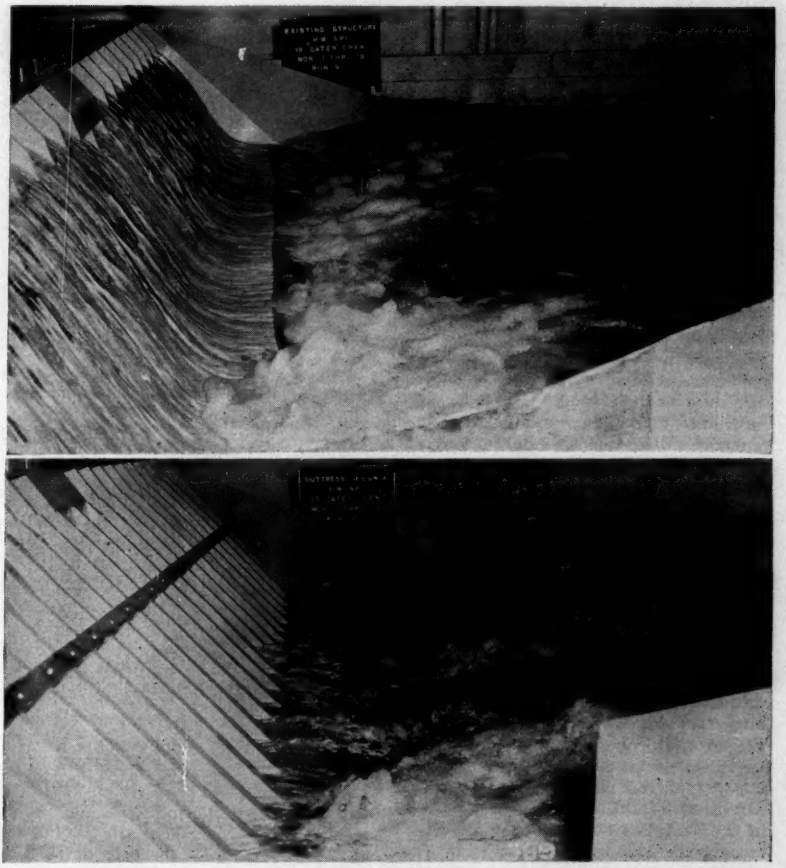
In this limited space, only the more important test results, with very little of the supporting data, can be discussed.

Effect of Buttresses on Stilling Basin

Tests on both the movable-bed model and the fixed-bed model indicated that, in general, erosive tendencies would be lessened by the addition of buttresses to the original spillway. The fairly obvious explanation of this conclusion lies in the observed effect of the buttresses in dividing the nappe into separate jets which discharged freely off the spillway bucket, falling on the tail-water blanket a considerable distance downstream from the end of the dam. Lack of free air below the continuous sheet of water passing across the original bucket resulted in negative pressures under the nappe, unstable flow and a lowered trajectory. When the results of these model tests were compared with the recorded performance of the original structure, it could be concluded only that conditions in the stilling basin would not be unfavorably affected by the proposed construction. Figures 5 and 6 are photographs which illustrate the characteristic differences in behavior of the original and the modified spillways. In these tests the model was operating at normal reservoir level (elevation 521), with all gates opened wide, resulting in a prototype flow of 172,000 cfs.

Design of Spillway Bucket Extension

As shown in Figure 2, the spillway bucket on the original structure was of minimum length and did not include any type of end sill or baffle blocks. As this bucket had to be lengthened from 13 to 23 feet (variable because of different elevations across the length of the spillway) just to accommodate the added buttresses, an important objective of the model tests was to develop a satisfactory design for the extension. The only type of sill considered for comparison with a horizontal extension was a simple "flip" sill with plane faces sloping up in the downstream direction. The design which was finally adopted called for the construction of a sill one foot high and six feet in base width in every bay except Nos. T, 1, 2, and 3 at the power-house end of the spillway. This design appeared to give optimum performance, considering scour, wave action and spray. The sills were omitted in the four bays nearest the power house in order not to increase the objectionable spray which



Figures 5 and 6. Illustrating the characteristic differences in behavior of the original (top) and the modified (lower) spillways as demonstrated by the 1:80-scale model.

normally occurs due to the unfortunate orientation of the power house with respect to the spillway. Sills in the bays nearer the opposite end of the spillway, where the bucket is also higher than the average, caused considerable spray in the model, but greatly reduced scour around the retaining wall. As these sills are far removed from the power house, spray was not believed to be a serious consideration.

Gate-Opening Sequence

The problem of determining a most satisfactory gate-opening sequence for flood-water release was, of course, limited to flows less than the full capacity of the spillway at top-of-gates level, elevation 521. The criteria for evaluating various gate-opening arrangements were, as for the foregoing objectives, surface currents, waves, spray and stilling-basin scour. The schedule of opera-

tion finally developed called for opening the gates in the following sequence: Nos. 10, 12, 14, 16, 18, 9, 8, 7, 6, 5, 11, 13, 15, 17, 19, 4, 3, 2, 1, T. The syphons can be opened at any time. The adopted sequence obviously develops quite logically, but it was made quite clear during the tests that undesirable flow conditions frequently result from gate arrangements which, without the benefit of the model studies, would appear to be just as logical. In the model, as in the prototype, it was demonstrated that gates adjacent to the power house should be the last to be opened.

A secondary objective of tests on the 1:80-scale model, which developed as the tests proceeded, involved the raising of the power-house training wall to resist and deflect spray and over-riding flow from spillway bays near the power house, which normally would be opened only during extreme floods. The final design for this modification called for raising the wall four feet and adding a four-foot over-hanging extension at the top to serve as a wave deflector. It is important to note that the necessity for this modification was due primarily to power-house orientation and not to the addition of buttresses on the spillway.

The height and location of cofferdams required for two-stage construction of the spillwey buttresses were also determined in brief tests on the 1:80-scale model. A unique result of this study was the enlargement of the cofferdam area to permit flooding of and discharge into the cofferdam areas in the event of the occurrence of a flood larger than could be passed through the unenclosed spillway bays. Fortunately, construction operations at the dam site did not have to be interrupted for a prototype check of this feature.

THE 1:40-SCALE MODEL

The second model was built to a 1:40 scale and was sectional, including one full bay and two adjacent half-bays of the spillway. This model was designed to be placed in an existing 3-foot flume. The crest section was constructed accurately in Lucite, and fifty piezometers were located on the spillway and buttresses for pressure measurements. The model was not equipped with a movable bed for scour tests. Figure 7 shows the crest section of the model before installation.

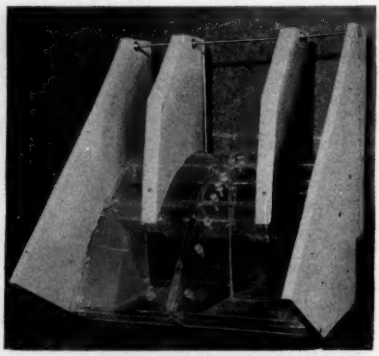


Figure 7. Crest section of the 1:40-scale sectional model before installation.

The principal objectives of tests on this model were:

(1) To measure hydraulic pressures on the faces of the dam and buttresses;
(2) To record the water-surface profiles for various conditions of flow over the modified spillway;
(3) To calibrate the spillway for free discharge and various gate-opening arrangements on the modified structure.

Pressures on Dam and Buttresses

Figure 2 includes the results of a typical test to determine pressures on the dam and buttresses. As indicated, piezometers were located on the centerline of one bay of the spillway and on the face of one buttress. Pressure data are plotted as piezometric profiles, with straight lines drawn between plotted piezometric observations. It is indicated that positive pressures exist over all of the spillway except a short reach below the crest. Considerably higher negative pressures were recorded with the headwater at maximum flood level, elevation 530. In the latter case, a maximum negative pressure head of (-) 6.40 feet was recorded at the fourth crest piezometer, located at the highest point on the spillway.

Continued on Page 24

DIGESTS OF GRADUATE THESES

CHEMISTRY

1949-1950

Digests of theses submitted during 1949-1950 in partial fulfillment of the requirements for the degree of Master of Science in Chemistry are presented below. This is the third in a series of features summarizing the graduate theses submitted last year to the various schools of the Georgia Institute of Technology.

Robert J. Athey, *The Absorption Spectrum of Nitryl Chloride*. Faculty advisor: Dr. W. H. Eberhardt.

The absorption spectrum of nitryl chloride, NO_2Cl, was investigated photographically in the visible and ultraviolet regions with a Cenco replica grating spectrograph. A continuum was found which extends from 3300 Å to a region beyond the 2200 Å limit of the apparatus. No band structure was observed. This strongly indicates that while the ground state potential function possesses a minimum, that function of the excited state does not.

The absorption coefficients were measured from 3000 Å to 2200 Å with a Beckman Model DU spectrophotometer. The absorption followed the Beer-Lambert Law. A plot was made of the absorption coefficient versus wave length, and the rapidity with which the coefficient rose with decreasing wave length indicated that the maximum lies beyond the 2200 Å limit of the equipment.

The infrared absorption spectrum was measured throughout the range of 1-15μ with a Beckman Model LR-2 spectrophotometer. Eight comparatively strong bands were recorded, with indications that a ninth lay just beyond the 15μ-limit of the instrument.

Of the six fundamental vibrations possessed by nitryl chloride (an asymmetric-top molecule of symmetry C_s^v), only one type B band was recorded. It was assumed that the other band lay just outside the range of the instrument.

Henry William Bartholomay, *Solubilities in the System Gallium-Mercury*. Faculty advisor: Dr. W. M. Spicer.

The compositions of the two immiscible layers formed when gallium and mercury are mixed were determined chemically to measure the mutual solubilities of these two metals and the effect of temperature on their solubilites. The composition of the mercury-rich layer was found to be 98.6 per cent mercury at 35° C., and there was essentially no change in the composition of this layer at 100° C. At 35° C., the gallium-rich layer contained 93 per cent gallium, while at 100° C. the solubility of the mercury increased slightly with a resulting reduction in the gallium content to 91.5 per cent.

These results indicate that the mutual solubilities of these two metals are very slight. For the solution of gallium in mercury, temperature has no noticeable effect; and, for the solution of mercury in gallium, higher temperatures increase the solubility of the mercury only slightly. The meagre solubility of these two metals in each other has been rationalized on the basis of large differences in their internal pressures.

William Morrisey Beaver, *Tertiary Alcohol Derivatives of 2-Acetyl Thiophene*. Faculty advisor: Dr. B. B. Wroth.

The synthesis of nine thienyl-substituted tertiary alcohols was accomplished through the Grignard reaction, and, since these carbinols had never before been prepared, a study was made of their properties. They were prepared by reacting a series of lower alkyl magnesium halides with 2-acetyl thiophene, hydrolyzing the resulting complex and purifying by fractionation under reduced pressure. Yields varied from 33 to 65 per cent, the best yields being obtained when alkyl bromides were used in place of iodides. The secondary and tertiary magnesium halides gave lower yields, in general, than did the normal isomers.

Densities and refractive indices were determined at 20° C. Molecular refractions

were calculated by means of the Lorentz-Lorenz equation. Boiling points were determined at reduced pressures with a Cottrell-type apparatus; and carbon and hydrogen determinations were made by means of the customary combustion apparatus. The di-alkyl-substituted 2-thienyl carbinols prepared were: dimethyl, methyl ethyl, methyl n-propyl, methyl isopropyl, methyl n-butyl, methyl sec-butyl, methyl ter-butyl, methyl n-amyl, and methyl n-hexyl.

Fa-wu Cheng, *The Extraction of Oil and Protein from Cottonseed by a Water-Grinding and Centrifuging Process.* Faculty advisor: Dr. N. Sugarman.

A water-grinding and centrifuging method for cottonseed processing was studied to find conditions suitable for separating the constituents into cottonseed, protein and meal. In this method the oilseed is ground in a suitable mill, the resulting slurry is clarified by passage through a centrifuge and the insoluble materials are separated as meal. After clarification, the oil is separated from protein and other components of the slurry by a centrifuging. The protein is recovered from the remaining materials in the oil-free dispersion by precipitation at its iso-electric point.

Experimental results indicate that grinding in slightly alkaline slurry is not desirable since the oil will usually be widely dispersed among the products; a supplementary grinding in a pebble mill in strongly alkaline slurry will reduce the oil content in cake to a great extent; preliminary grinding at a pH value lower than seven will decrease the oil content in the protein. The quality of oil and meal produced by this method is good in comparison with the quality of those produced in ordinary processes; the gossypol content in both oil and meal is very low, but in the protein it is high enough to necessitate further purification.

Bert M. Cottrell, Jr., *The Preparation of Certain Esters of 2-Thiophene Carboxylic Acid.* Faculty advisor: Dr. B. B. Wroth.

The methyl, propyl, butyl, amyl, hexyl, and heptyl esters of 2-thiophene carboxylic acid, not previously prepared, were synthesized and pertinent physical data determined. The Fischer method of esterification was used in which the alcohol and acid are heated under reflux in the presence of three per cent dry hydrogen chloride as a catalyst. The physical data taken included boiling points, densities and refractive indices. Two methods of identification of the new esters were used: (1) determination of the experimental molar refractions and comparison with the calculated theroretical molar refractions; and (2) determination of the saponification numbers.

The purity of the methyl, propyl, butyl, and amyl esters was considered high and the physical constants very accurate. However, because of the modified method of extraction that had to be adopted for the hexyl and heptyl esters, some doubt exists regarding the purity of these esters. Saponification calculations indicate that these two esters are approximately 96-98 per cent pure, which is considered acceptable for organic compounds. Further research is anticipated.

Jerome Kruger, *An Azeotrope in the System Bromine-Carbon Tetrachloride.* Faculty advisor: Dr. W. M. Spicer.

This study had as its purpose the discovery and isolation of an azeotrope of bromine. The first system investigated was that of bromine-carbon tetrachloride. An azeotrope was believed to exist in this system because it exhibits a large deviation from Raoult's Law due to a great internal pressure difference and the fact that the boiling points of the two components are fairly close together. Through the use of an equilibrium still described in the literature, it was discovered that an azeotrope did exist in the system. The azeotrope was prepared, using a fractionating column, and found to exhibit a boiling point of 57.7° C. at 735.6 mm. and a bromine content of 88.8 per cent (by weight). Chemical reaction in the system at the temperatures involved was shown to be nonexistent. An increase in volume over the ideal volume was noted for the azeotropic mixture.

John Edward Varner, *A Critical Study of the Copper Spark Method of Spectrographic Analysis.* Faculty advisor: Dr. W. M. Spicer.

Copper electrodes have been in use in spectrographic laboratories for a number of years, the principal advantage being freedom from interference by cyanogen bands. Since

the accuracy of the copper spark method as a quantitative spectrochemical technique has not been sufficiently explored, the purpose of this research was to make a critical study of the method with respect to precision and accuracy.

Stock solutions of nickel in an iron solution were prepared and analyzed by the copper spark method, and the accuracy was compared with that obtained in an analysis of nickel in steel using National Bureau of Standards samples. The latter determination was performed by the conventional spectrochemical method, and is considered to be one of the most precise of all spectrochemical determinations.

The results of this study were the discovery of those experimental conditions which yield the most precise results and an estimation of the accuracy and precision of this method as compared with that obtained by the conventional method in a very favorable case; namely, the determination of nickel in National Bureau of Standards steels. Data are presented together with working curves which would prove useful in the analysis of nickel in an iron solution. A new device for facing the electrodes is described, which eliminates the difficulty involved in machining the copper electrodes.

Stanley Oscar Winthrop, *A Study of the Condensation of Thioisophthalaldehyde*. Faculty advisor: Dr. J. A. Stanfield.

The preparation of w, w, w^1, w^1-tetrabromo m-xylene by direct bromination of m-xylene was studied. The reaction conditions finally attained gave a yield of 53 per cent of the desired product. Two new thioaldehydes, monothioisophthalaldehyde and dithioisophthalaldehyde, were prepared. Their properties were determined and each compound was analyzed for carbon, sulfur and hydrogen. Several attempts were made to condense dithioisophthalaldehyde by heating with copper powder or Raney nickel in a manner that would lead to the cyclic dimer, diphenylene diethene. However, these attempts were unsuccessful.

CLEANING FARMERS' STOCK PEANUTS

Continued from Page 4

Mechanical Methods

For cleaning peanuts mechanically, three machines were developed which can be used jointly or in conjunction with existing machinery.

The **air-blast cleaner** utilizes a high-speed stream of air flowing in a horizontal direction to exert varying forces on the material dropped into it, depending on the area, shape and density of the objects. The net result is that rocks, peanuts, sticks and light trash can be made to fall into four compartments. About 85 to 90 per cent of the peanuts are separated from the foreign matter by this process which is essentially a form of fractionation. Supplementary processing is necessary to recover the relatively small percentage of peanuts remaining with the foreign material.

This method promises large-volume cleaning with cheap and simple equipment. At the same time it employs a machine which can be adapted for use on large or small volumes of peanuts.

When a batch of peanuts is subjected to the air-blast cleaner, the lighter peanuts and most of the sticks fall into the same compartment. The **V-corrugated slot screen** shown in Figure 2, was built to recover these peanuts from the sticks. The screen consists of a V-corrugated bottom with guide strips on the apexes of alternating corrugations. Open slots of the desired width at right angles to the travel of the product allow the peanuts to fall through while the corrugations and guide strips align the sticks axially in the direction of travel and cause them to ride over the slots. A second purpose is served by the guide strips which extend over the slots: any stick which does not align in the proper direction rides on the guide strips and is carried over the slots. Air, blown at low velocity upward through the slots, floats many short and smaller sticks across the slots. This type screen is preferably vibrated at low ampli-

tude and high frequency. The V-corrugated slot screen is non-clogging and has as great capacity and greater efficiency than flat screens now in use.

Tests of the air-blast cleaner indicated that additional equipment was needed to supplement the cleaning operation. One such need was for a sizing or grading machine of high capacity to separate the loose kernels and stones under ¼ inch in diameter from the whole peanuts. A **rotary-disc screen** having flat discs equally spaced on a rotating shaft has been found to perform this separation satisfactorily. Fingers extending into slots between the discs dislodge any particles that have a tendency to stick, and a clean surface is always presented to the incoming product. Objects too large to fall between the discs are carried over the top, and small particles fall between the discs and exit through a lower chute. This screen, shown on the cover of this issue, has a high capacity and is non-clogging in operation.

PILOT MODELS

Full-scale pilot models of the air-blast cleaner and the slot screen have been developed in cooperation with the Red Diamond Mills at Cordele, Georgia. The two units, in conjunction with a destoner, are being tested for use in cleaning farmers' stock peanuts prior to purchase. More test data are required before publication of tabulated results. However, loads of peanuts containing as high as 40 per cent foreign material have been cleaned at the rate of 12 to 15 tons per hour with reduction in foreign material content to less than three per cent.

Concurrently, a full-size pilot-model rotary-disc screen has been constructed in cooperation with the East Georgia Peanut Company of Statesboro, Georgia, for use as a sizing machine. Preliminary tests reveal that rapid and effective sizing can be accomplished with negligible damage to the product.

These mechanical methods of cleaning farmers' stock peanuts are versatile and easily applied on the farm, or in the normal shelling-plant operation. Although they were designed primarily for peanuts, the methods' basic principles can well be applied to the cleaning of other seeds.

* * * * *

Further investigations are being conducted on the problems of shelling and mechanical picking for quality. An industrial engineering survey of a number of shelling plants in Georgia is now under way.

SOLVENT EXTRACTION—A NEW METHOD

Continued from Page 6

with the type of oilseed being processed. In general, all seeds must be cleaned carefully to remove such foreign matter as leaves, stems, stalks, stones, sticks, etc. All seeds have a protective coating variously known as a hull, husk or shell. With many seeds, peanuts and cottonseed for example, it is necessary that this coating be removed, a process termed decortication. All seeds must be milled for the double purpose of reducing the size of the seed particles, thus exposing more surface area, and of cracking the coatings on seeds which are too small to decorticate economically. Many combinations of seeds and extraction units also require that the oleaginous material be tempered, or heat treated. However, the conditions are rarely, if ever, as rigorous as those employed in the various mechanical expression processes.

Some oilseeds, such as soybeans, can be extracted successfully with no preliminary treatment other than cleaning, cracking, tempering and flaking. However, it has been found economical to subject other varieties of oleaginous materials, particularly those having medium or high oil contents, to mechanical pressing (forepressing) prior to solvent extraction. This procedure has been practiced for years in Europe, with low-pressure screw presses being the principal mechanical expression equipment. Until

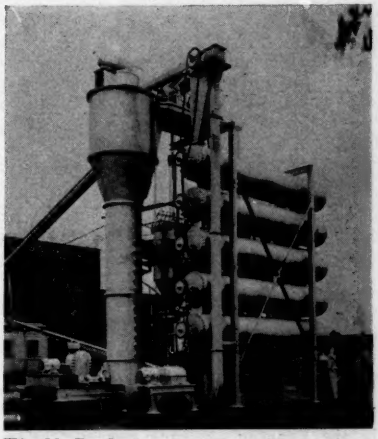
fairly recently, American designers have attempted to produce extraction units which could handle oilseeds without recourse to forepressing. Lately, some manufacturers have begun to offer continuous screw presses as an integral part of their extraction systems. This has been particularly true in the extraction of cottonseed oil.

Extraction Units

The purpose of extraction units is to bring the seed mass into intimate contact with the solvent and to maintain this contact until the maximum amount of oil has been dissolved. Needless to say, it is desirable that this be accomplished in a minimum of time.

One of the most popular extractors is the German-developed Bollman type which consists of a series of baskets moving vertically on an endless chain in a vapor-tight housing. The material to be extracted is placed in the baskets and sprayed at intervals with either pure solvent or an oil-solvent mixture known as the half-miscella. About half of the American solvent extraction plants utilize either the original Bollman design or improved "Bollmans" manufactured by either the French Oil Mill Machinery Company of Piqua, Ohio, or the Blaw-Knox Construction Company, Pittsburgh, Pennsylvania. Inasmuch as many of these units have a relatively high capacity (up to 600 tons per day), approximately 85 per cent of our annual domestic production of solvent-extracted oil is obtained from extractors of this type.

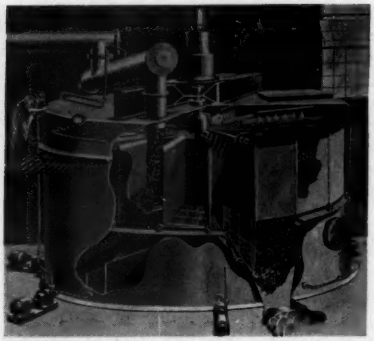
The Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, and the V. D. Anderson Company of Cleveland, Ohio, have each developed an extractor which consists essentially of a vertical column divided into a number of compartments by horizontal slotted plates. The seed mass is fed into the top of the column while pure solvent is pumped in at the bottom. The seeds descend the column through the slots, aided by slow-moving paddles which revolve just above the surface of the plates. The miscella is discharged at the top of the column, while the spent seed flakes are removed at the bottom. The Anderson unit is quite novel in that it is designed for



The V. D. Anderson extractor is a compact unit designed for outdoor operation.

location outdoors, which reduces the capital investment required. For processing seeds having a high oil content, the V. D. Anderson Company has recently developed the "Exsolex" process which utilizes a screw press specifically designed to produce a cake which may then be rolled into highly extractable flakes. This differs from the usual forepressing operation in that it comprises a group of operations which are controlled, within certain limits, for the extraction of oil from high-oil-content seeds. Another unit, the Bonotto extractor, having a design somewhat similar to both the Allis-Chalmers and Anderson extractors is currently being marketed by the Production Engineering Company of Memphis, Tennessee. However, the Bonotto differs in a number of ways, one of the most marked being that it utilizes revolving horizontal plates, each of which is equipped with a stationary baffle to aid in the movement of the material being processed.

With the exception of some specially designed variants (rectangular and horizontal basket units) developed by the French Oil Mill-Machinery Company, all of the extractors described above have the disadvantage of being rather tall; for example, the conventional basket-type extractor requires the equivalent of a five-story build-



Cut-away drawing of the Blaw-Knox "Rotocel" extractor.

ing. This disadvantage has been overcome in the Kennedy extractor presently being manufactured by the Vulcan Copper and Supply Company, Cincinnati, Ohio. The Kennedy unit consists of a long, horizontal, vapor-tight compartment, the lower part of which is subdivided into a series of troughlike sections running crosswise. The material to be extracted is fed into one end of the unit and is carried along by means of impeller wheels mounted in each section. Countercurrent extraction is accomplished by introducing the solvent at the opposite end of the extractor.

A rather novel horizontal unit has been developed by the Blaw-Knox Construction Company, which also markets a basket-type extractor. This "Rotocel" unit employs a rotor, five feet in height, which revolves slowly inside a vapor-tight tank. The rotor is divided into 18 sector-shaped cells into which the material to be extracted is fed in the form of a slurry, with miscella constituting the liquid phase. As the rotor revolves, the oleaginous material is washed with portions of miscella and with a final portion of pure solvent. The oil thus obtained, together with the accompanying solvent, drains through perforations in the bottom of each cell and collects in compartments beneath the rotor.

As mentioned previously, it is frequently necessary to resort to forepressing when handling seeds having a relatively high oil content. To eliminate the necessity for double handling, the Sherwin-Williams Company, Cleveland, Ohio, has developed and placed in operation an extractor specifically designed for seeds containing large percentages of oil. In this system, the oilseeds are first ground in the presence of the extracting solvent. The slurry thus formed is fed through a series of three extraction units; each extraction unit consists of a mixer, in which the ground oleaginous material is brought into intimate contact with either miscella or pure solvent, and a centrifuge, which is employed to separate the resulting miscella (or enriched miscella) from the partially extracted residue.

All of the units described above were designed for fairly large-scale operations; namely, 50 tons per day minimum. Considerable interest has been shown from time to time in extractors having a capacity of 50 tons or less. This interest has resulted in the development of several small-sized units which, conceivably, could be operated by either a single farmer, a co-operative group or a community. Although the Ford Motor Company pioneered in this particular field, no Ford extractors have been in operation since 1946. However, the Detrex Corporation, Detroit, Michigan, the Crown Iron Works Company of Minneapolis, Minnesota, and the French Oil Mill Machinery Company, Piqua, Ohio, all produce small-scale units. In the Detrex system, the seed mass is conveyed through the horizontal, tube-like extractor by means of a screw conveyor, while in the Crown unit, which was developed by the Iowa State Engineering Experiment Station, a chain conveyor in a looped extraction tube is utilized. The French extractor is a modified basket-type model in which the principal direction of movement is horizontal rather than vertical. The Detrex and Crown extractors utilize nonflammable trichloroethylene as a solvent, which appears to be a definite advantage in units operated by relatively unskilled personnel.

Numerous other extractors have been designed and built. Several of these—Hildebrandt, Tyca, MIAG, Bohm and Fauth—are of foreign origin and, with the exception of the Hildebrandt, have never been operated in this country. The Hildebrandt

extractor, consisting essentially of a U-shaped tube through which the material being extracted is moved by a series of screw conveyors, is primarily of interest for historical reasons—the first unit to be operated successfully in America was a Hildebrandt. Several oil mill operators have designed and built their own extraction units. One of the more successful of these is that of the Sessions Brothers' Company of Enterprise, Alabama, in which peanut meal from continuous screw presses is extracted. Another unit of the same design, now under construction, will be used with soybeans.

Oil and Solvent Separation

After the miscella, or oil-solvent mixture, leaves the extractor, it must be separated into its components, preferably using a minimum of heat. The processes employed differ in detail; but, in general, the first step is one of filtration or clarification designed to remove any solid particles, or "fines," which have been entrained in the miscella. At this point the miscella consists of about 20-30 per cent oil and 80-70 per cent solvent. It is next concentrated in an evaporator until the oil content rises to 85-90 per cent. The equipment varies and may include either multiple- or single-tube units operating on either the rising- or falling-film principle. The remaining solvent is removed by stripping with steam, usually in a packed column which is frequently operated under vacuum. Finally, the solvent is separated from all accumulated water and returned to a storage tank for subsequent re-use in the extractor.

Meal and Solvent Separation

Meal leaving the extraction unit normally contains 25-35 per cent solvent. Since mechanical separation is much more economical than the use of thermal methods, the meal is allowed to drain for an interval prior to being introduced into the thermal solvent-removal unit. Many systems employ steam-jacketed drier tubes through which the meal is passed by means of ribbon or paddle conveyors. Some of these units are equipped so that a vacuum may be applied, and virtually all remove the last traces of solvent with a direct application of steam. Other extraction systems employ drum-type desolventizers which are said to operate somewhat more efficiently than the tube-type units. Regardless of the removal method utilized, the solvent is finally freed from moisture and solid matter before being returned to the storage tanks.

APPLICABILITY TO SPECIFIC OILSEEDS

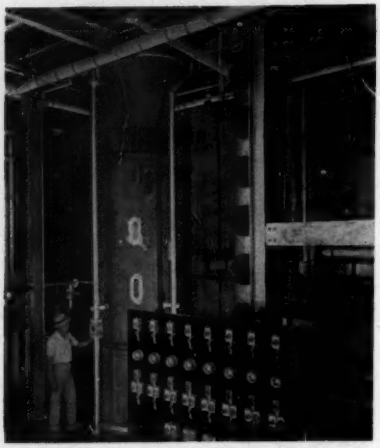
Statements are frequently encountered in the literature that all types of oilseed have been solvent extracted successfully, on a commercial basis, in Europe. However, in European practice, virtually all seeds except soybeans are forepressed; hence, in many instances, solvent extraction is actually applied to mechanically expressed residues rather than to the original oilseeds. Solvent extraction practice in America is slightly more complex with the result that generalized statements are difficult to make, and the picture for each oilseed should be considered separately.

Soybeans

Virtually all of the problems inherent in the solvent extraction of soybeans have been solved, and practically any manufacturer of an extraction system will guarantee the performance of his unit with this oilseed.

Cottonseed

Cottonseed present several difficulties which are not encountered in the processing of soybeans: the greater oil content resulting in more friable flakes, the troublesome linter coat, and the presence of numerous pigments. Because of these problems, solvent extraction of cottonseed on a commercial basis was not given serious consideration until about ten years ago. The advent of World War II delayed building of the first unit (Delta Products Company, Wilson, Arkansas) until 1944. Operation of the plant began some three years later, but the direct solvent extraction of cottonseed did not prove to be economical. Accordingly, the system in use was replaced by an Exsolex unit, described above as a recent development by the V. D. Anderson Company. This is said to have resulted in a vast improvement. Direct extraction left a residue containing 2.6 per cent oil, while the meal now being obtained has an oil content of only 0.3 per cent. The Exsolex



Allis-Chalmers extractor installed in a western Tennessee soya mill.

process is also more economical than direct solvent extraction in that the solvent losses are less, as are the quantities of steam and water required.

The Buckeye Cotton Oil Company has also been active in the solvent extraction of cottonseed oil and has apparently been successful, as evidenced by the current construction of a 150-ton plant at Augusta, Georgia. According to information obtained from the manufacturer, the French solvent extraction system is employed in all of the Buckeye plants.

In addition to the plants already mentioned, several other extractors are handling cottonseed. These include at least three Allis-Chalmers units and one Kennedy extractor. A 400-ton per day Exsolex system is scheduled to go on stream at Sherman, Texas, in the not-too-distant future. Neither Blaw-Knox nor Sherwin-Williams extractors are known to have been operated for extended periods on cottonseed, but these manufacturers have stated that their units are capable of handling such seeds.

Thus, it might be said that while the solvent extraction of cottonseed is still in the developmental stage, the prospects are bright that this type of oleaginous material can be handled on a commercial basis.

Peanuts

The oil content of peanuts is considerably higher than that of either cottonseed or soybeans (approximately 50, 30 and 18 per cent, respectively) with the result that it is almost impossible to form a flake which is sufficiently durable to withstand handling in an extraction unit. Therefore, progress in the solvent extraction of peanuts has not been as marked as that with the oilseeds referred to above. Although a detailed discussion of the economic aspects of the various oilseeds is beyond the scope of this survey, it should be noted that the principal uses for peanuts are in edible products—peanut butter, candies, or salted nuts—and that peanut oil is normally derived from such sources as excess stocks, nuts of substandard size, etc. This is in decided contrast to cottonseed and soybeans which are primarily of value because of their oil content. It therefore seems reasonable to assume that economic as well as technological reasons have delayed the widespread application of solvent extraction to peanuts.

Apparently there are no commercial establishments engaged in the full-time, direct solvent extraction of peanuts. However, the Sessions Brothers' Company processes peanut cake on a continuous basis, and the aforementioned Exsolex plant at Sherman, Texas, is designed to handle peanuts in addition to cottonseed. Several oil mills equipped with French extractors have been listed as part-time processors of peanuts, but it was not definitely stated whether the actual raw material was peanuts or peanut meal.

The results of pilot-plant studies carried out with a Kennedy extractor indicated that raw peanuts could be processed satisfactorily —a residue containing 0.58 per cent oil was obtained. Sherwin-Williams has stated that no serious obstacles were encountered in the processing of peanuts in their extractor; and the Allis-Chalmers unit is said to be usable, provided the nuts are properly prepared.

As may be seen, the solvent extraction of peanuts is still largely in the experimental stage. It would appear from a study of all aspects of the situation that a logical step would be development of a fairly small

unit—possibly similar to either the extractor of the Crown Iron Works or the Detrex unit—which could be operated on peanut residues in conjunction with existing mechanical expression equipment.

Tung Nuts

Although tung nuts, which are grown in fairly restricted areas in the South, constitute a rather valuable source of oil, only a comparatively small amount of work has been done on the solvent extraction of tung oil. A series of experiments carried out in the early 1940's with a pilot-plant-sized Kennedy unit yielded a high-quality oil; but it was found that certain precautions were necessary to obtain oil with a relatively low acid content, since oils which were excessively acid tended to solidify soon after being extracted.

Miscellaneous Oilseeds

A number of other oilseeds which are not important crop-wise in the South are now being handled successfully on a commercial basis in solvent extraction equipment. These include flaxseed (French, Sherwin-Williams and Exsolex), castor beans (Sherwin-Williams), rice bran (Allis-Chalmers), copra (Detrex), corn germs (Allis-Chalmers and Hildebrandt) and cocoa residues (Kennedy).

ECONOMIC ASPECTS

Soybeans are the only oilseed for which any extensive economic data on solvent extraction have been published. These data are not directly applicable to the South's major oilseeds, since soybeans are comparatively easy to solvent extract.

The primary reason that solvent processes are favored is that they give increased oil yields. The processing cost for a ton of soybeans is slightly greater in a solvent plant than in an installation equipped with screw presses. However, this increase is more than offset by the greater return realized from the additional oil.

In evaluating economic data concerning the solvent extraction of soybeans, it should also be noted that processing costs are nearly always compared with costs of screw press operations. This hinders use of these data for cottonseed and peanuts, since the majority of our Southern oil mills use hydraulic presses rather than continuous screw machines.

One Southern oil mill operator stated that in his case (solvent extraction of meal) the prices of oil determined whether or not his solvent plant made a profit, since it cost a definite amount to extract the additional quantity of oil. When the price of oil was such that he could not cover this extra expense, the operation became uneconomical. This argument will probably be true in all instances where a solvent extraction plant is merely added to an existing mechanical expression installation. However, in a plant specifically designed for solvent extraction it is conceivable that the operating costs will be very nearly equal to those of a mechanical plant. If this is the case, the solvent extraction plant should continue to show a profit under more adverse conditions than a mechanically equipped competitor, due to the additional quantity of oil obtained from each ton of oilseed processed. The crux of the problem, therefore, appears to be operating costs, including amortization of the original capital investment (estimated installation costs for a 200-ton plant vary from $400,000 to $700,000). It may be assumed that organizations such as Buckeye Cotton Oil Company and Delta Products Company would not continue to pour their money into solvent extraction plants if they felt that they could not operate on a competitive basis.

FUTURE TRENDS

Several trends in the solvent extraction of oilseeds are now discernible. One of these is the increased utilization of small-scale extractors. For example, two Crown units are now in operation and two more are under construction, although this process has only been available for about one year. Another trend of more importance to the South is the recent appearance of solvent extraction in the processing of seeds other than soybeans.

Since cottonseed, peanuts and, to a lesser extent, tung nuts are highly important crops in this area, any processing change which will increase their saleability should mean increased revenue for the farmer as

well as a more profitable operation for the oil mill operator. Thus, solvent extraction —a new method in an old industry—may well be a key which will aid the South in opening wider the "door" to a stabilized economy through expansion of its agricultural program and industrial potential.

DAM MODEL TESTS

Continued from Page 14

Very high pressures, of course, were observed in the bucket and the adjacent face of the buttress. However, stresses in the buttresses due to hydraulic forces were insignificant in the structural design. Tailwater had no effect on the measured pressures because it was washed off the bucket for all conditions of operation.

Surface Profiles and Discharge Calibration

Typical water-surface profiles along the centerline of one bay and adjacent to the face of one buttress are also shown on Figure 2. This information was used, in part, to insure adequate clearance for the lateral struts which were located between the buttresses.

The spillway was calibrated for the following conditions of gate operation:

(1) All gates open;
(2) Center gate open, both adjacent half-gates closed; and
(3) Center gate and one half-gate open, one half-gate closed.

As the gates are never used for part-gate operation, all tests were made for free discharge conditions. Coefficients of discharge computed on the basis of the simple weir formula had an average value of 3.7 at normal pool level and approximately 4.2 at maximum flood level. The latter figure, an unusually high coefficient of discharge, is obviously a consequence of the aforementioned negative pressure on the crest.

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The Company's investigations were made under the direct supervision of Mr. Harrison, Hydraulic Engineer, and under the general direction of Mr. W. P. Hammond, Vice-President, Georgia Power Company. Consulting engineers were S. H. Woodard, O. G. Thurlow, and N. F. Williams. Prof. Kindsvater was in charge of the model studies which were conducted in the Georgia Tech Hydraulics Laboratory by arrangement with the Georgia Tech Research Institute and the State Engineering Experiment Station.

STATION NEWSBRIEF

With our November issue editorship of THE RESEARCH ENGINEER passed from B. H. Weil to a close friend and long-time professional associate, John C. Lane.

Mr. Lane, former head of the Information Service of the Institute of Gas Technology, Chicago, succeeds Mr. Weil as head of the State Engineering Experiment Station's Technical Information Service.

Mr. Weil, who had served as editor of THE RESEARCH ENGINEER since its inception in May, 1946, has assumed new duties as supervisor of the Ethyl Corporation's Information Division.

GOVERNMENT-FINANCED RESEARCH

Continued from Page 2

However, much has been accomplished through projects sponsored by individual companies or industrial associations, and the state funds which were available have been used to the fullest advantage in acquiring the facilities necessary for broad-ranged research.

The Board of Regents of the University System of Georgia has recently requested an appropriation to aid the Georgia Tech Engineering Experiment Station in expanding its services to the people of the State, the South and the Nation. It is hoped that this appropriation will be made and that others will be granted regularly in the years to come. . . . For it is certain that success of the Station projects now under way and those which can be made possible by increased funds will contribute to a more bountiful life for all.